

Effects of High Winds

In buildings, the threat to life caused by tornadoes is due to a combination of effects which happen at almost the same time. Expert interpretations of building damage establish the following tornado effects, *in order of importance*.

EXTREME WINDS

Even the most modern building codes do not require buildings to withstand the winds of a tornado. Many buildings have been erected without the requirement to meet any building code. As a result, it isn't surprising to see that almost all buildings are no match for a tornado.

These extreme winds almost always rotate in a counter-clockwise direction. Entire buildings are affected by the severe winds. The wind speed increases with height, causing maximum damage potential on the top floor of a building.

WINDWARD WALLS usually face south and west. However, east and even north walls can be windward, depending on the size and location of the storm and the building. The glass, bricks, and block that make up these walls will be blown into the interior of the building.

LEEWARD WALLS usually face north and east. The winds tend to pull these sides outward. The pressures here are much smaller than on the windward side. The net result is therefore less damage to the leeward walls. The windows on these walls usually blow out.

Severe damage can occur to the leeward walls if the windward walls are penetrated. This *filling-the-balloon* effect is an added powerful force which can blow out the back walls.

ROOFS, especially flat roofs and those with a slight slope, tends to be lifted up and carried away. Overhangs, and eaves on the windward side are the most vulnerable, and compound the uplift problem. Roofs with steep slopes are somewhat less vulnerable to up life, but can be blown sideways.

Lightweight roofing materials, such as gravel, wood, insulation, shingles, and steel deck, often are lifted and thrown hundreds of feet in all directions by tornadoes. The weight of concrete roofs tends to resist uplift.

MISSILES

The high-speed whirling winds of a tornado can turn almost anything or anyone into a missile. Automobiles, buses and tractor trailers can be tumbled about. Portions of buildings become airborne at high speed. Exterior wall materials on the windward sides often are thrown into building interiors.

Missiles move much faster horizontally than vertically. Also, many more missiles move horizontally.

Therefore, it is more serious to have a wall missing than a roof insofar as protection from missiles is concerned.

Missiles are a major threat to life. Fortunately, they usually are stopped by substantial, somewhat massive interior partitions. Buildings without such interior partitions can be death traps.

COLLAPSE

Portions of buildings may fail during a tornado and collapse upon other spaces in a building. Chimneys collapse frequently, spilling their massive debris onto the roofs of adjacent spaces.

Higher portions of buildings may collapse onto adjacent lower spaces, adding extreme loads to already weakened roof systems.

PRESSURE DIFFERENCE

A tornado usually is a localized low-pressure storm in an overall low-pressure system. The atmospheric pressure inside a building exceeds the outside pressure, causing the building to tend to *explode*. Little is known about the magnitude of the pressure drop, since operating barographs rarely have survived a tornado.

Building *explosions* due to atmospheric pressure differences have probably been greatly overstated. Almost all damage can be explained from the extreme winds, missiles, and collapse. The pressure difference does occur however, it is not proper to open windows, to help equalize the pressure.

The somewhat predictable action of the winds, missiles, collapsing elements, and pressure differences make possible the identification and design of protected spaces for human occupancy. These *best-protected spaces can be identified and should be occupied during a storm*. People should not be randomly distributed throughout a building. They should move to preselected locations offering best-available protection. This does not mean that the best available shelter in all buildings is good enough to protect life. Some single-story lightweight buildings, especially modular houses and classrooms, should be evacuated and the *occupants should seek shelter elsewhere*.